

I. LANGMUIR.
 INCANDESCENT LAMP.
 APPLICATION FILED SEPT. 4, 1913.

1,246,118.

Patented Nov. 13, 1917.

Fig. 1.

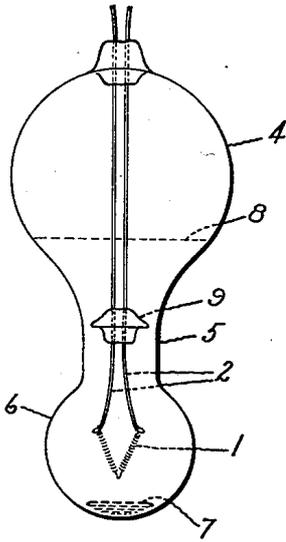


Fig. 2.

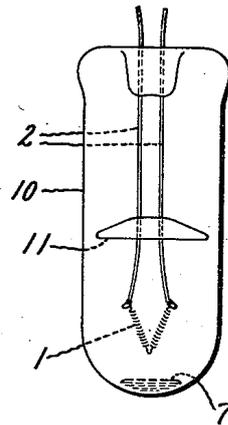


Fig. 4.

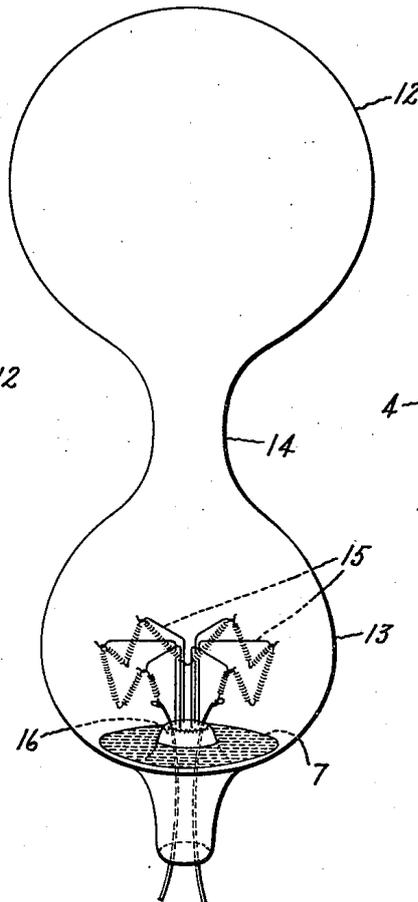


Fig. 3.

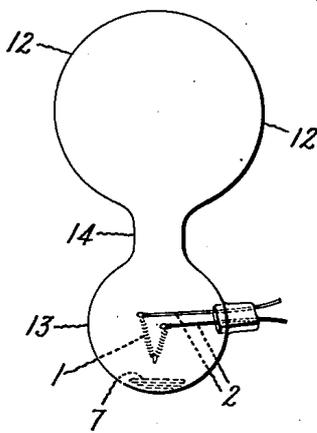
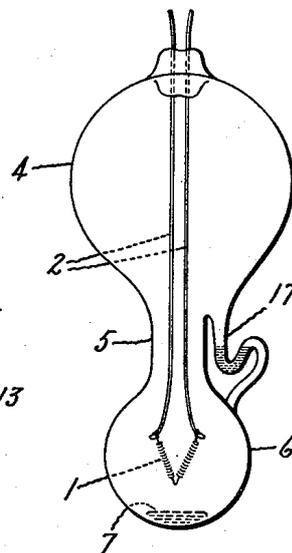


Fig. 5.



Witnesses:
 Margaret A. Delehauly
 Fred Parout

Inventor:
 Irving Langmuir,
 by Albert G. Damon
 His Attorney.

UNITED STATES PATENT OFFICE.

IRVING LANGMUIR, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

INCANDESCENT LAMP.

1,246,118.

Specification of Letters Patent.

Patented Nov. 13, 1917.

Application filed September 4, 1913. Serial No. 788,165.

To all whom it may concern:

Be it known that I, IRVING LANGMUIR, a citizen of the United States, residing at Schenectady, in the county of Schenectady, State of New York, have invented certain new and useful Improvements in Incandescent Lamps, of which the following is a specification.

My invention relates to incandescent electric lamps and more particularly to lamps having filaments of refractory material such as tungsten.

In my prior Patent 1,180,159, issued April 18, 1916, I have disclosed a lamp which has its filament so fashioned as to size, shape and material and surrounded by an atmosphere of nitrogen or mercury vapor that the filament can be run at a much higher temperature and at a higher efficiency than would otherwise be possible.

My present invention comprises certain improvements whereby the vapor of a substance such as mercury may be conveniently and effectively created and utilized in a lamp of this character.

The use of an atmosphere of mercury presents the marked advantage that it operates in some way to protect the filament from the effect of any water vapor that may be present in the lamp. Since mercury vapor is monatomic it is not dissociated even at the highest temperature attained by an incandescent tungsten filament. It is a poor conductor of heat, and at suitable pressures it causes the rate of evaporation of a tungsten filament to be much lower than the rate at which such a filament evaporates in a vacuum or even in an atmosphere of inert gas. Mercury vapor at atmospheric pressure, for example, has a very great effect in preventing such evaporation.

According to my invention, I place in the lamp bulb a small quantity of the substance, mercury for example, to be vaporized by heat from the filament, and I introduce into the lamp some suitable inert gas, such as nitrogen or hydrogen or a mixture thereof, which will absorb enough heat from the filament to prevent it attaining a dangerously high temperature before the mercury vaporizes, and I construct the lamp in such a way that the mercury vapor when produced displaces the nitrogen or other inert gas, so that, except momentarily at starting, the filament operates in an at-

mosphere of the vapor of the mercury or similar material.

For a better understanding of my invention, reference may be had to the accompanying drawings in which, for purposes of illustration, I have shown some of the many different forms in which my invention may be embodied. Figure 1 is a view of one form of lamp embodying my invention, and Figs. 2, 3, 4 and 5 are views of modified forms of lamps embodying my invention.

In the particular form of lamp shown in Fig. 1, a filament 1, preferably of drawn tungsten, is connected to and carried by comparatively stiff heavy leads 2, preferably made of tungsten or other highly refractory metal. The filament must be either of relatively large cross-section, for example, 10 or 20 mils in diameter or larger, or if not of large cross-section, then it must be so fashioned, as by coiling into a close helix, shaping into a tube either split or otherwise, as to give the same effect with respect to exposed surface. This is for the reason, as I have found, that, within limits, a large cross-section filament loses heat by convection and conduction practically no faster than a filament of small cross-section, but as its light radiating surface is much greater than that of the smaller filament, its efficiency as a luminant is therefore much higher. It is this factor as well as the high temperature which the filament can sustain without prohibitive vaporization under the conditions of operation which enables a higher net efficiency to be obtained than is possible if the same filament were operated in a vacuum.

Referring again to Fig. 1, the leads 2 are hermetically sealed, as indicated conventionally in the drawings, into the walls of the lamp bulb, usually made of material such as glass or quartz. Any suitable seal may be employed, the particular seal to be used forming no part of my present invention. In the particular form of bulb shown the leads 2 are sealed into the wall of an upper portion or condensing chamber 4 which is connected through a constricted passage or neck 5 with the lower or bulb portion 6. This lower portion 6 is immediately adjacent the filament 1 and constitutes the light transmitting portion of the bulb. A quantity of material such as mercury 7 is placed in the bulb portion 6 close enough to the filament 1

to be vaporized by heat from the filament. The bulb portion 6 is of such a size and so proportioned that when the lamp is in operation its walls are kept at such a temperature by the heat from the filament that the mercury or other material will not condense on these walls, consequently the mercury vapor passes through the constricted neck 5 into the upper or condensing chamber 4 and is there condensed. When the lamp is in operation the mercury vapor may normally extend to about the level of the dotted line 8, the cooling and condensing action of the walls of the chamber 4 being sufficient to condense practically all of the mercury vapor before it rises any higher.

In some cases it may be desirable to place a baffle or similar device 9 adjacent the constricted portion or neck 5 in order to control the flow of mercury vapor from the lower bulb or chamber into the upper condensing chamber, whereby it sweeps up into the upper chamber as a sort of blast and carries with it any water vapor or foreign gas that may be liberated in the lower bulb. This baffle may assume many different forms, one simple form being that shown in the drawing in which a disk or plate of glass is secured to the leads 2 in such relation to the neck 5 as to produce the desired effect on the flow of mercury vapor.

As there is practically no mercury vapor around the filament when the lamp is cold, I avoid injury to the lamp as a result of running the filament without the atmosphere of mercury vapor for the short period of time between the turning on of the current and the evolution of the mercury vapor by putting into the lamp, as I have heretofore mentioned, in addition to the mercury, an atmosphere which will surround the filament whenever the mercury vapor does not do so, and which will protect the filament until the appearance of the atmosphere of mercury vapor at suitable pressure. I prefer to use for this purpose some inert gas like nitrogen which does not diffuse into the mercury vapor to an objectionable extent, and does not attack the filament or the leads. Hydrogen may be mixed with the nitrogen because of its good heat conductivity. I prefer so to proportion the lamp that when it is in normal operation the contents are at about atmospheric pressure as in general the higher the pressure of the mercury vapor the better the efficiency of the lamp. The pressure of nitrogen is in any event such that when current first flows through the filament the nitrogen will conduct heat away from the filament so rapidly that the filament does not reach a dangerous temperature while the mercury is being vaporized to produce the proper atmosphere. In accordance with my invention I cause the nitrogen or other gas to move away from the neighborhood of the

filament as quickly and as completely as possible after the lamp is lighted, and thereafter run the filament in mercury vapor alone, so that I am able to obtain much higher efficiencies and better results than are possible where nitrogen or similar gas is in contact with the filament all the time the lamp is lighted. The mercury vapor is approximately seven times as heavy as the nitrogen, and displaces the nitrogen, forcing it up away from the filament and into the upper chamber 4. None of the mercury vapor can condense upon the hot walls of the bulb portion 6 as long as the lamp is lighted, but condensation does take place in the upper or condensing chamber 4 to such an extent that the mercury vapor forms a line of demarcation as, for example, at 8. The filament then runs at very high temperature in an atmosphere of mercury vapor at about atmospheric pressure, or whatever pressure is selected as most suitable, while the nitrogen remains practically quiescent in the upper part of the condensing chamber 4 and out of contact with the filament until the lamp is turned off, whereupon the mercury vapor condenses, the mercury collects in the bottom of the bulb portion 6, and the nitrogen again fills the bulb portion 6 and surrounds the filament 1.

The nitrogen gas, in addition to its important function in preventing injury to the filament when the lamp is started into operation, serves to equalize the pressure in the bulb against the cooling effects of drafts and against the changes of temperature of the external atmosphere with changes in the seasons as from summer to winter or the like. It has, in short, a sort of cushioning effect, the result of which is that as the mercury vapor pressure rises the nitrogen is compressed and thus more condensing surface, in the bulb 4 for example, is exposed as the line 8 rises, whereby increase in mercury pressure is checked. The opposite effect occurs when the external conditions tend toward greater cooling of the bulb. The gas cushion has still another important effect in preventing arcing between the filament ends because if properly proportioned, it prevents the pressure in the bulb from becoming, under any conditions, as low as to render arcing possible. Thus when the lamp is cold and practically no vapor of mercury is present, the gas pressure must be above the arcing point. This pressure is somewhat indefinite but nevertheless very considerable. The pressure should be not less than several centimeters and preferably such as to give atmospheric pressure or thereabout when the lamp is running.

When the lamp is lighted, the bulb portion 6 is so hot that very considerable amounts of water vapor and occluded gases may be driven out of its walls. If the mercury va-

por were not present, the bulb 6 would blacken very quickly, probably as a result of the action of this water vapor, but when the mercury is present the lamp may run for
 5 hundreds of hours without blackening. The mercury vapor seems to prevent the harmful effect of occluded gases or water vapor given out by the walls of the bulb. I do not wish to advance or to be restricted to any
 10 particular theory as to the reason for the observed facts, but probably the blast of mercury vapor keeps the water vapor away from the filament, and, the vapor rushing up
 15 into the condensing chamber 4, carries with it any deleterious gases or water vapor which may be present, so that such gases or vapors are deposited in the condensing chamber before they have an opportunity to
 20 exert any harmful effect upon the filament or light giving portion of the bulb. It is also possible that in some way not clearly understood the mercury vapor counteracts and nullifies the effect of water vapor and
 25 other deleterious gases and vapors. At any rate, the evaporation of the filament, the heat loss, and the harmful effect of the water vapor are all much less when the filament is surrounded by mercury vapor than when it
 30 is in contact with gas, such as nitrogen.

In the particular modification shown in Fig. 2 a substantially cylindrical bulb 10 is divided into two communicating chambers or compartments by a kind of baffle or partition 11 mounted in any suitable way, as
 35 for example, on the leads 2. The operation of this lamp is substantially the same as that shown in Fig. 1. When the lamp is started into operation the nitrogen surrounding the filament 1 absorbs heat and prevents overheating of the filament until
 40 the mercury vapor generated by the heat of the filament rises and displaces the nitrogen, driving it into the upper part of the bulb. As long as the lamp is running the filament
 45 is surrounded by an atmosphere of mercury vapor at suitable pressure. When the lamp is turned off, the mercury condenses and the nitrogen again fills the whole bulb 10 and surrounds the filament 1 ready to perform
 50 its function when the lamp is again turned on.

Fig. 3 shows a modification in which the lamp consists of two chambers 12 and 13 in
 55 substantially the form of an hour glass. The leads 2 enter the side of the bulb 13 and the constriction or neck 14 between the bulbs permits the mercury vapor to force the nitrogen into the upper condensing
 60 chamber 12 from which the condensed mercury falls back into the bulb portion 13. As shown in this figure the constriction or neck between the bulb and the condensing chamber of a lamp embodying my invention
 65 can be so proportioned that there is no ne-

cessity for a baffle corresponding to the baffle 9 of the lamp shown in Fig. 1.

Fig. 4 shows another form of lamp having a bulb substantially like that shown in Fig. 3 and with the leads entering through
 70 the bottom of the bulb 13 instead of through the side. The filament is mounted in the bulb 13 in a suitable way, as for example, on supports 15 made of tungsten or other refractory wire and secured to a cen-
 75 tral stem 16. The filament in this figure, as in the other figures of the drawings, is shown as coiled into a helix of small diameter and with the spires close together as already pointed out. It is to be observed,
 80 however, that wherever the filament is sharply bent or is passed over supports as at 15 it is not coiled. Certain structural features of the lamp involving the contour of the filament and its support are described
 85 and claimed in a divisional application, Serial No. 154,606, filed March 13, 1917. The mercury 7 surrounds the stem and is so related to the filament that it vaporizes when the lamp is turned on and the filament be-
 90 comes incandescent.

Fig. 5 shows a modified form of lamp which is in general similar to the lamp shown in Fig. 1. The mercury vapor gener-
 95 ated in the transparent or light-giving portion 6 passes up through the neck 5 into the condensing chamber 4. In this particular modification I make special provision for returning the condensed mercury through a
 100 passage separate from that through which mercury vapor enters the condensing chamber. One particular arrangement which may be used is that shown in the drawing, in which a mercury trap 17 permits the con-
 105 densed mercury to return to the lower bulb portion 6 but prevents the passage of mercury vapor up into the condensing chamber. By this arrangement the condensed mercury is returned to a definite point in the bulb
 110 6, while solid impurities carried by the condensed mercury float on the mercury in the trap 17 and are prevented from passing down into the lower bulb.

What I claim as new and desire to secure by Letters Patent of the United
 115 States, is:

1. An incandescent lamp comprising a bulb, a gas therein, non-condensable at ordinary temperatures, a material having in the vapor state a poor heat conductivity and
 120 being condensed at ordinary temperatures, a light-giving body so located with respect to said material that said body will be surrounded by the vapor thereof to the substantial exclusion of said gas when the bulb
 125 is heated to the operating temperature.

2. An incandescent lamp comprising an elongated bulb, a gas therein, non-condensable at ordinary temperature, a material having a poor heat conductivity in the vapor
 130

state, and being condensed at ordinary temperatures, a light-giving body located near one end of said bulb adjacent said material, and being completely enveloped by the vapor of said material when at incandescence.

3. An incandescent lamp comprising a bulb having two portions communicating with each other through a constricted passage and containing two fluids differing in density the denser fluid being of materially poorer heat conductivity than the other, said bulb being shaped to permit one of said fluids to displace the other from one of said portions of the bulb when the lamp is lighted, and a refractory metal filament of large effective diameter mounted in one portion of said bulb in a position to be surrounded by the heavier of said fluids while the lamp is lighted.

4. An incandescent lamp comprising a bulb provided with two chambers communicating with each other through a constricted passage and containing two substantially non-diffusing atmospheres of different densities, and a refractory metal filament of large effective diameter mounted in one of said chambers in a position to be surrounded by the denser atmosphere while the lamp is lighted.

5. An incandescent lamp comprising a bulb having communicating chambers and containing an inert gas, a condensable substance in the bulb adapted to volatilize during operation of the lamp, and a refractory filament in said bulb the space above the filament being constricted so that the blast of vapor thereby produced sweeps away from the vicinity of the filament any water vapor or deleterious gases than may be freed during operation of the lamp.

6. An incandescent lamp comprising a bulb, a refractory metal filament therein of large effective diameter, a vaporizable material in said bulb adapted to be volatilized when the lamp is operated, and a gas cushion operating at all times to prevent the variation in pressure due to variation in the volatilization of said vaporizable material from becoming such as would cause danger from arcing.

7. An incandescent lamp comprising a bulb, a refractory metal filament therein of large effective diameter, a vaporizable material in said bulb, and a gas cushion operating so that the pressure in the lamp is at

all times above that at which arcing would occur and not less than that corresponding to several centimeters of mercury.

8. An incandescent lamp comprising a bulb having a filament chamber and a condensing chamber, a refractory filament of large effective diameter in the filament chamber, a vaporizable material in the bulb, and a gas cushion whereby the condensing surface for said vapor automatically changes with the pressure in the bulb.

9. An incandescent lamp comprising a bulb having two chambers communicating through a constricted passage and containing an inert gas of considerable pressure, a tungsten filament of large effective diameter mounted in one of said chambers, and a substance in the filament chamber which volatilizes when the lamp is lighted to produce a dense atmosphere which drives said inert gas out of said chamber and away from the filament and completely surrounds the filament while the lamp is lighted.

10. An incandescent lamp comprising a bulb having a light giving chamber and a condensing chamber, a filling of inert gas in said bulb sufficient in quantity to partially fill said condensing chamber at a predetermined pressure, a body of mercury in said light giving chamber, and a refractory metal filament of large effective diameter mounted in said bulb in thermal relation to the mercury to volatilize the mercury and thereby produce a dense monatomic atmosphere of poor heat conductivity which at said predetermined pressure drives the inert gas into said condensing chamber.

11. An incandescent lamp comprising a bulb having a light giving portion and a condensing portion in communication therewith through a constricted passage, a filling of inert gas in said bulb, a body of mercury in said light-giving portion, and a filament of tungsten of large effective diameter mounted in said light giving portion in position to vaporize said mercury and to heat said light giving portion to a temperature which prevents deposition of mercury thereon.

In witness whereof, I have hereunto set my hand this 30th day of August, 1913.

IRVING LANGMUIR.

Witnesses:

ALEX. F. MACDONALD,
ALEXANDER D. LUNT.